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BIOTROPISM.

By LYMAN C. WOOSTER, Ph. D.

WHEN Lamarck declared, in 1801 and 1809, that the effects of use and disuse on cells and organs are inherited, he raised such a storm of opposition that followers of Lamarck have been few from that time to the present. Indeed, Lamarck's theory has been killed many times, but always there have been a few faithful disciples ready to assist in its resurrection. Paleontologists have found Lamarck's theory so perfectly in accord with what they find in the crust of the earth that they, as a class, have followed his leadership in most things, styling themselves Neo-Lamarckians.

An increasing number of biologists in this twentieth century follow Lamarck in his contention respecting the inheritance of the effects of use and disuse of cells, organs and the individual; and declare, with him, that it is life (Aristotle's entelechy) that is the efficient agent in the modification of species to meet a changing environment, and that life is the bearer of such modifications, making possible their continued inheritance.

But the larger number of biologists (it is strange that they class themselves as biologists) maintain that the entelechies are the products of the chemist's crucible, and that environment, including the physical forces, is the chief agent in the development of the life powers. College textbooks on plant and animal physiology are loaded with discussions of geotropism, heliotropism, phototropism, thigmotropism, traumatropism, rheotropism, chemotropism, hydrotropism, aërotropism, thermotropism, and several other external influences, while not in a single textbook, not even in the latest dictionary, will be found biotropism, a perfectly legitimate word.

When a root pushes through the soil toward the center of the earth, this movement is said to be an example of geotropism, not biotropism; when a house plant bends toward a sunny window, the textbook makers say that it does so because of phototropism, and do not hint of biotropism, though the more careful ones admit that there is an inexplicable element in the problem.

This mechanistic tendency of so many human minds is probably due to the great preponderance of culture subjects in school and college curricula of the past several hundred years. The mathematical formulæ, especially, apply so readily in the explanation of the action of the physical forces, and the atomic theory serves the chemist so beautifully in the working out of his chemical reactions, that many old-time college-made biologists very naturally turn to these chemical and physical forces for the causes of vital phenomena. Hence we have the germ-plasm theory of Weismann, the laws of Mendel, and the attempts to find life in the crucible made by Loeb and Schaefer. The chemical and physical forces can be measured and expressed in terms of standard units, while life, a variable, does not lend itself so readily to the mathematically minded for expression.

Chemists, physicists and astronomers know that chemism, cohesion and adhesion, gravitation, all forms of radiant energy, and the influence that controls the arrangement of molecules in crystals, all obey laws that have not varied since the beginning of exact human observation. Every one, on the other hand, who has Aristotle's entelechy within him, knows that life is a variable which may do things differently to-morrow from what it does them to-day, in both instances under precisely the same external conditions.

This variability of life is worrying some of our modern biologists. Doctor Driesch, the great German vitalist, in a letter to Lovejoy, of Johns Hopkins University, says, in an excerpt quoted by Jennings, also of Johns Hopkins, and published in *Science* for October 4, 1912: "You are quite right in saying 'the biologist can not from the kowledge of total physical configuration predict what will happen even after he ha sobserved it.' This is, indeed, a consequence of my vitalism, and I am glad that you appreciate it. I reject absolute indeterminism, but accept experimental indeterminism." In their published correspondence in *Science*, continued for two or three years, neither Jennings nor Lovejoy gives any reasons for the fact that experiments on living organisms do give results of high certainty.

In several papers[1] read before this Academy during the past eight years I have reiterated the belief that the first activities of the first cell of protoplasm on earth must have been performed consciously; later, when these activities have been performed consciously many times, they became in part habitual in the individual, and by contined repetition through many generations they became largely subconscious and instinctive tendencies in the species.[2] We can merely prophesy as to the course of conscious activities in others; we can be fairly sure as to the form of movement of the subconscious activities; and can be nearly certain as to the ends that will be reached by the instinctive activities. The uncertainties in the second and third forms of activities are due to slow modifications of subconscious and instinctive powers by repeated additions and subtractions. Man shows in his body nearly one hundred and twenty vestigial parts, according to Wiedersheim, and sixty others whose functions are changing. But these slight daily variations in the subconscious and instinctive activities of plants and animals, with corresponding changes in the body parts, do not prevent successful experimentation with these organisms. This is common experience, and the fact that Jennings himself has been exceedingly successful in his experiments with lower organisms emphasizes this conclusion without in the least impairing the validity of indeterminate vitalism.

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[1] Volume XIX, The Genesis and Development of Human Instincts. Volume XXI, Part I, Antiquity of Man's Body-building Instincts. Volume XXII, Weismann's Germ-plasm Theory Untenable. Volume XXIV, Origin and Development of Plant and Animal Instincts.

[2] Dr. Charles S. Minot, of Harvard, in his presidential address before the American Association for the Advancement of Science, in 1902, at Pittsburg, says, as a probable hypothesis, that conscious actions are primary; reflex or instinctive actions secondary; or, in other words, that for the benefit of the organism, conscious actions have been transformed into instincts and reflexes."

The conscious additions and subtractions to the various subconscious and instinctive forms of activity have another, though related, effect which is highly important in biology. These changes in the ego following the conscious use or disuse of parts finally result in the evolution of many new varieties, subspecies and species of plants and animals. These new forms are preserved through the inheritance of instincts modified consciously in the direction of greater efficiency, through isolation by means of barriers, and by the greater success of these organism, in their struggles for existence.

Many biologists deny the efficiency of consciousness in bringing about the evolution of new species, because they forget that consciousness, according to Doctor Minot, has the power to change the form of energy without itself being a form of energy or a state of protoplasm. From the simplest organisms, whether plant or animal, to most complex, consciousness is the directing influence. In organisms along the lines of ascent up to but not including man, with his powers of speech, and in the living protoplasmic cells of all organisms, including those of man's body, needs are felt, and met, not by a course of reasoning requiring language, but by a somewhat blind feeling that the action felt to be best is the one to be taken.

If consciousness did not have this power with race and individual memory to direct race and individual development, there could be no orthogenetic evolution. The bodies of organisms, however complex, could not be built from the simple fertilized egg cell, and cells of complex organisms could not modify their internal structure and multiply in number to meet increased needs nor fail to do so when disused. All our notions of efficiency compel us to believe that there are cell egos as well as individual egos to consciously superintend the multiform activities of every organism composed of many cells.

Man in some respects is in a class by himself. Language, with its rich supplies of concepts, is such a help to the conscious powers that this lord of creation can determine by a course of reasoning what is best to be done long before his body can evolve parts with which to do it. So he makes external provisions for his needs, and many of his body cells and organs, except those of his brain, stop evolving higher powers. It is for this reason that man's body is on a level with the world of animals, while his mind has kinship with the God of the universe.